2006

The role of herbaceous woodland perennial diversity for improving nutrient uptake capacity of riparian areas

Cathy Mabry McMullen
Iowa State University

Jan Thompson
Iowa State University

The role of herbaceous woodland perennial diversity for improving nutrient uptake capacity of riparian areas

Abstract
This project investigated the roles of forest understory perennial plant communities in storing nutrients and preventing pollution of surface waters.

Keywords
Natural Resource Ecology and Management

Disciplines
Natural Resources and Conservation | Plant Biology

LEOPOLD CENTER
FOR SUSTAINABLE AGRICULTURE

The role of herbaceous woodland perennial diversity for improving nutrient uptake capacity of riparian areas

Abstract: This project investigated the roles of forest understory perennial plant communities in storing nutrients and preventing pollution of surface waters.

Question & Answer

Q: Is it feasible for farmers to improve the function of riparian buffers by adding shade tolerant perennial herbaceous species?

A: This study suggests that these perennial herbaceous species will improve seasonal nutrient storage in buffers. Additional work by these researchers is investigating which of these species play a key role in nutrient retention and methods for reintroducing them.

Background

Nutrient pollution of surface water is a significant midwestern problem. One potential solution is to establish perennial vegetation at strategic points in the landscape. However, the emphasis has been on woody species, particularly when establishing forested buffers. The researchers considered whether nutrient interception by buffers and forests could be enhanced by the addition of shade-tolerant herbaceous perennials.

The study to examined the potential role of herbaceous perennials in nutrient uptake. Objectives were to

1. Quantify the nutrient uptake of understory perennial plants,
2. Quantify the role of spring ephemeral species in early-season nutrient dynamics, and
3. Compare nutrient uptake capacity of intact woodlands (with diverse native herbaceous flora) to that of disturbed woodlands (typically with low diversity, a natural "proxy" for constructed buffers).

Approach and methods

The study was conducted in three central Iowa woodlands where intact and disturbed forests occur in close proximity and were located along high order streams. One was at the Conard Environmental Research Area located near Grinnell in Jasper County. Another was at Robison Wildlife Acres, a preserve donated to Story County in 1970, and a portion of this area was heavily grazed prior to acquisition. The third woodland sampled was a privately owned parcel near Ames in Story County that has a restored forested slope that had been grazed prior to 1965.

Researchers on this grant estimated nutrient storage of nitrogen, phosphorus, and potassium by the forest perennial herbaceous layer. The scientists examined three sets of paired plots where intact woodlands were located close to disturbed woodlands. All species present on 20-meter by 20-meter plots were identified. Herbaceous perennials located in eight 0.5 meter by 0.5 meter quadrants in each of the larger plots were harvested (in early spring and again in midsummer), dried, separated into above- and below-ground plant parts, and weighed to determine biomass. The dried samples then were analyzed to determine total nitrogen, phosphorus and

Principal Investigator:
Cathy Mabry McMullen

Co-investigator:
Jan Thompson
Natural Resource Ecology and Management
Iowa State University

Budget:
$18,000 for year one

Table 1. Mean biomass (g/0.25m$^{2)}$ of forest herbaceous plants for three intact versus three disturbed forests in central Iowa, U.S.A. Numbers in parentheses are ± 1 SD.

	Intact	Disturbed
Spring		
above ground	14.9 (8.8)	5.7 (4.9)
below ground	24.5 (19.7)	6.0 (2.1)
Summer		
above ground	11.6 (4.9)	10.9 (6.4)
below ground	23.6 (19.3)	6.3 (4.5)

potassium content of the plant tissues, and this was combined with biomass to estimate the total amount of nutrients stored.

Results and discussion

Above-ground biomass was more than two times greater and below-ground biomass was four times greater in intact versus disturbed woodlands in early spring. In summer, below-ground biomass was still four times greater in the intact forests (Table 1). Plant tissue concentration for the nutrients studied did not differ between site types. Thus, biomass differences resulted in overall nutrient storage nearly three times greater on the intact sites. The disturbed sites were missing an entire group of species, the spring ephemerals, and this accounted for much of the difference in biomass and nutrient storage between intact and disturbed sites.

The study demonstrated large differences in the nutrient storage capacity for nitrogen, potassium, and phosphorus on intact versus disturbed sites. This exploratory study also provided support for the hypothesis that spring ephemerals are especially important for nutrient storage in forests because the site differences were driven by biomass differences that could be attributed to spring ephemerals. This work also suggested that there may be some spring-growing species that are not true ephemerals, and also made a significant contribution to nutrient retention in spring. These grow in early spring along with ephemerals, but they persist and maintain vegetative growth throughout the summer, and have the capacity to continue nutrient uptake and retention over a longer period of time. These species, along with true spring ephemerals, were more abundant, and therefore produced more biomass on intact versus disturbed sites. Some of these species, such as *Hydrophylum virginiana*, also may be important in the fall when they produce additional vegetative growth.

Previous work funded by the Leopold Center in 2002 demonstrated that some species in the group of early spring herbaceous perennials are particularly sensitive to cattle grazing and other work suggests that they are sensitive to urbanization. It appears that many of these species may be unlikely to re-colonize on their own, suggesting that they may need to be actively restored to newly constructed and restored woodlands.

Conclusions

The principal conclusion is that perennial herbaceous species, because of the biomass they accumulate during the growing season, have the potential to improve the capacity of riparian buffers to seasonally store nutrients and prevent them from entering surface waters. Because the degraded forests in the study were lacking a group of species that have peak growth in early spring, their capacity to retain nutrients was seriously impaired in the spring, a time of high potential nutrient loss.

Impact of results

The results achieved the project objectives and showed that perennial herbaceous species have significant nutrient uptake capacity, and that important differences can be detected between sites with intact understory vegetation and sites that have disturbed or degraded understories. With this preliminary data in hand, it will be possible to develop a broader research program on the role of herbaceous perennials in preventing water pollution from agricultural runoff.

The next steps should be to determine if there are key functional species in healthy, diverse woodland systems and if those species are missing in degraded or early successional or constructed (riparian buffer) systems. The potential for restoration of those species should be investigated. The ultimate goal should be to make recommendations for (re)introducing native perennial herbaceous species (based on their functional effectiveness) to enhance the function of disturbed woodland areas, early-successional forests, and riparian buffers, and to devise demonstration projects that include these species.

Education and outreach

The work of one graduate student was partially supported by this grant and the resulting M.S. thesis reports on the work of this project. All three project investigators collaborated on a journal article submitted to the *Canadian Journal of Forest Research*

Results from the project have been communicated to agencies (such as the Iowa Department of Natural Resources Bureau of Forestry) that assist landowners with management decisions. Iowa State collaborators working on USDA and college-funded programs were informed about the initial project results.

Leveraged funds

Pioneer Community Investment contributed $5,000 to support this project. In addition, the investigators were able to use this project to leverage an additional $10,000 from Pioneer for subsequent work in the same area.

For more information, contact Cathy Mabry McMullen, Natural Resource Ecology and Management, Iowa State University, Ames, Iowa 50011; (515) 294-1604, e-mail mabry@iastate.edu